

(12) **United States Patent**
Sudhoff et al.

(10) **Patent No.:** **US 10,003,291 B2**
(45) **Date of Patent:** **Jun. 19, 2018**

(54) **HYBRID SURFACE MAGNET MACHINE**

(71) Applicant: **Purdue Research Foundation**, West Lafayette, IN (US)

(72) Inventors: **Scott Sudhoff**, West Lafayette, IN (US);
Steve Pekarek, West Lafayette, IN (US); **Omar Abdul Laldin**, Inglewood, CA (US)

(73) Assignee: **PURDUE RESEARCH FOUNDATION**, West Lafayette, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days. days.

(21) Appl. No.: **15/693,923**

(22) Filed: **Sep. 1, 2017**

(65) **Prior Publication Data**

US 2018/0013367 A1 Jan. 11, 2018

Related U.S. Application Data

(63) Continuation of application No. 14/668,367, filed on Mar. 25, 2015, now Pat. No. 9,780,715.

(60) Provisional application No. 61/969,894, filed on Mar. 25, 2014.

(51) **Int. Cl.**

H02K 21/12 (2006.01)

H02P 23/00 (2016.01)

H02P 25/022 (2016.01)

H02K 21/04 (2006.01)

H02K 16/02 (2006.01)

H02P 9/14 (2006.01)

(52) **U.S. Cl.**

CPC **H02P 23/009** (2013.01); **H02K 16/02** (2013.01); **H02K 21/042** (2013.01); **H02P 25/022** (2013.01); **H02P 9/14** (2013.01)

(58) **Field of Classification Search**

CPC H02K 21/042; H02K 16/02; H02P 23/009; H02P 9/14

USPC 310/156.01–156.84, 181
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,663,605 A * 9/1997 Evans H02K 1/223
174/DIG. 21
5,753,989 A * 5/1998 Syverson B60L 11/12
310/114
6,072,257 A * 6/2000 Akemakou H02K 1/22
310/156.55
9,780,715 B2 * 10/2017 Sudhoff H02K 21/042
2006/0119206 A1 * 6/2006 Akemakou H02K 21/042
310/181
2011/0031843 A1 * 2/2011 Liang H02K 1/2766
310/216.096

(Continued)

Primary Examiner — Hanh Nguyen

(74) *Attorney, Agent, or Firm* — Purdue Research Foundation

(57) **ABSTRACT**

A hybrid electrical machine containing surface mounted magnets which includes a magnetically permeable cylindrically shaped stator assembly having at least one stator winding formed about a plurality of stator teeth, a rotor assembly concentrically disposed within the stator assembly, including a magnetically permeable rotor backiron, a rotational drive mechanism coupled to the rotor backiron, and a plurality of protruding rotor poles, each including a magnetically permeable pole support assembly, a winding provided around the pole support assembly, and a radially magnetized permanent magnet assembly disposed about the pole support assembly.

6 Claims, 9 Drawing Sheets

